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COMPLETE SPECIFICATION

Improved process for Applying a Thermoplastic Inner Lining to Pipes made of Non-Thermoplastic Material

We, TUBOVIT SOCIETA PER AZIONI, an Italian Body Corporate, of 2 Via Omenoni, Milan, Italy, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process for lining non-thermoplastic pipes, in particular metal pipes, with a thermoplastic synthetic resin liner, particularly of polyvinyl chloride (briefly designated as PVC) or of other vinyl resins. As is well known such liners are very difficult to apply because the pipes to be lined are neither perfectly straight nor perfectly round, and also because metals, such as iron, steel or aluminium or the other non-thermoplastic materials that may be used, have thermal expansion coefficients highly different from those of PVC or other vinyl resins: for these and other reasons the pipes and their liners tend to separate the ones from the others in operation.

The process according to the invention comprises the steps of passing a synthetic resin liner having a mean outer diameter, as herein defined, greater than the inside diameter of the non-thermoplastic pipe through a die having an inside diameter less than the original mean outer diameter of the resin liner and less than or substantially equal to the inner diameter of the non-thermoplastic pipe, after having heated said resin liner to a temperature at which the synthetic resin undergoes deformations which may be temporarily set by cooling but are substantially eliminated by subsequent heat treatment, introducing the synthetic resin liner after its passage through the die into the non-thermoplastic pipe and subjecting the resin liner, when it has been inserted in the non-thermoplastic pipe, to a heat treatment comprising the steps of bringing said resin liner to a temperature sufficiently high so that the deformations due to the passage of the liner through the die are eliminated to the extent allowed by the presence of the non-thermoplastic pipe.

Theoretically, since the resin liner shrinks on cooling, it might be permissible to use even a " die " having a diameter slightly greater than the inner diameter of the metal pipe and, the expression " substantially equal " is to be construed in the claims as including this latter case, though in practice the non-uniformity in diameter of the metal pipe render the introduction of resin liners calibrated with a die having a diameter greater than the inner diameter of the metal pipe, very difficult.

The heating must take place at a temperature which, for rigid PVC, that is, PVC free from plasticizer of the grade at present available on the market, is preferably comprised between the Vicat softening point, hereinafter more precisely defined, and 140° C., but may be even higher.

The upper limit acceptable for the temperature is determined by the actual possibility of handling the thermoplastic liner and of applying to it a high enough traction or pressure to cause it to pass through the die, because, when the temperature is exceedingly high, the plastic liner becomes so yielding and soft and has so low a tensile strength that it is nearly impossible to pass it through the die without tearing it or causing intolerable deformations. Not only, but, should the temperature be very excessive, a partial decomposition of the PVC or other resin may occur. This limiting point can be easily determined by experiments for each individual kind of plastic material. For rigid PVC, 200° C. is certainly too high; 180° C. may be very close to the upper limit.

The criteria for determining the temperature suitable for plastified PVC, which are lower than those referred to above, and for other plastic materials to which the process of the invention is applicable, such as vinyl copolymers and interpolymers, particularly polyvinyl chloride, polyvinyl acetate copoly-

mers, vinyl chloride or vinylidene chloride copolymers, or polyethylene, will be set forth hereafter.

It can be stated, in general, that, for every polymer there should be selected the temperatures at which the polymer has a mechanical behaviour, particularly a plasticity, comparable to the behaviour of rigid PVC at the temperatures above specified.

Means can be provided for rapidly cooling the resin liner after its passage through the die; in some instances the spontaneous cooling of the liner will be sufficient.

We wish it to be understood that, when reference is made herein to "diameters" mean diameters are always intended, because the metal pipe may be, but in general is not, perfectly round, while the resin liner never is. The tolerances for the diameter of the resin liners such as are available on the market, are in general about 3 per cent; this means that these tolerances are of the order of magnitude of the difference between the original mean outer diameter of the resin liner and the inner diameter of the metal pipe employed according to this invention. One of the characteristic features of the process of the invention is that the irregularities in the diameter of the resin liner have little importance as the liner becomes regularized in diameter as it passes through the die. Likewise, the possible irregularities of the inner diameter of the metal pipe have little importance as, should the die be distinct from the opening of the metal pipe, it may be chosen with a diameter not higher than the minimum inner diameter of the metal pipe at any point and along any direction; whereas the opening of the metal pipe acts as the die, the resin liner adapts itself to the irregularities in the cross-section of said metal pipe.

From this standpoint, it is to be noted that the word "die", as used throughout this specification, is not limited to perfectly circular openings, but can also be applied to openings which are only approximately circular.

After having been drawn through the die; the resin liner (which is now reduced to an outer diameter equal to, or slightly different from, the inner diameter of the metal pipe), is introduced into the metal pipe. According to an embodiment of the invention, the metal pipe is held by a suitable support in the immediate neighbourhood of the die immediately after said die and coaxially therewith: in this way the resin liner is caused to pass through the die and is introduced into the metal pipe by a single operation. According to a particular embodiment of this invention, the die is formed by a collar, or other device affixed to the opening of the metal pipe, and which can be removed after the introduction of the resin liner or can be left in place permanently; or the die may be the opening itself of the metal pipe or a flange applied internally of said opening.

After having introduced the resin liner within the metal pipe, the assembly of the two pipes is subjected to a heat-treatment at a temperature which may be near the temperature at which the liner had already been heated before being passed through the die, or which may be even considerably lower, provided that it is in any case higher than, or substantially corresponding to, or even a little lower than the Vicat softening point, the definition of which is well known to all those skilled in the art, but will be none-the-less recalled later.

Such heat treatment can be effected by heating or even, without a heating proper, by causing the liner to remain at the temperature of the treatment for a sufficient length of time during its cooling after having been passed through the die. Thus, if the resin liner is introduced into the metal pipe after having been calibrated and without prior cooling and the metal pipe is maintained at the temperature of the final treatment, the resin liner cools down only to that temperature and remains at that temperature for a certain time, being thus subjected to the desired final treatment. In some cases it is not even necessary to heat the metal pipe purposely, as the heat retained by the resin liner after its passage through the die, may suffice. In other words, if the cooling of the resin liner after its passage through the die takes place within the metal pipe and is sufficiently slow (this depends upon the temperatures adopted, the thermal capacities of the pipe and liner at the speed at which the resin liner is introduced into the metal pipe), the final heat treatment occurs during said cooling without the need of other operations. In general, however, the results thus obtained are not the best and it is therefore advisable to carry out the final heat treatment at a controlled temperature.

After this operation, the liner and the metal pipe adhere to one another and remain adherent in any operating conditions, so that it is necessary but to perform finishing operations, such as applying flanges, forming collars or preparing joints, which operations will be not described as they depend upon the process of this invention. Subsequently however a thermal-mechanical treatment at a lower temperature may be carried out, which will be explained later.

The method will now be described for determining the temperature at which the liner of PVC or other plastic material is to be heated before being passed through the die.

PVC, as it is well known, gradually softens by heating, becoming more and more plastic and mouldable: it has not, strictly speaking, a sharply defined melting point. It is customary to speak of a "softening point" of the several types of PVC, but this temperature is not an exactly defined quantity as it depends upon the method of measurement and, further there is not a conventional method universally

accepted by all, but there are different methods, each of which corresponds ot certain standards. One of the best known and adopted methods for determining the softening point is the Vicat method which is based on the penetration of a point in a small plate of PVC: the rules for the measurement of the Vicat softening point are well known to those skilled in the art. The softening point according to Vicat is the temperature at which a metal rod having a square cross-section with sides of 1 mm. each, loaded with a weight of 1000 grams, penetrates by a depth of 1 mm. into a plate of the material being examined, when the temperature of the material is raised (in a bath of a non-swelling liquid, in general oil) at a rate not higher than 4° C. every 5 minutes.

The Vicat point of the rigid PVC available on the market ranges from 88° C. to 92° C. and is lower for PVC that is plastified but still rigid enough to be processed according to this invention, and also for chloride-acetate copolymers, by some degrees Centigrade or even by some tens of degrees Centigrade, while it is considerably higher for vinyl-chloride-vinylidene chloride copolymers. Polyethylene melts more sharply so that the Vicat point is close the melting point.

If a piece of PVC is heated to its Vicat softening point or in the neighbourhood thereof, is subjected to mechanical deformation and is then cooled in a deformed condition, the piece returns the shape which has been imparted to it. But if the same piece is successively heated to the Vicat softening point (or to a higher temperature), in non-constricted state, it resumes, wholly or in part, its primitive shape. The material thus shows a "plastic memory" i.e. it is capable of assuming, at these temperatures, but labile deformations which a cooling sets only temporarily, and which disappear, at least partially, when the material is again heated in non-constricted state. This is what is understood herein by the expression "plastic memory".

If the deformation is brought about at higher temperatures the phenomenon at first continues to occur to the same extent but, when the temperature is considerably increased, it tends to become attenuated, i.e. the material tends to become permanently deformed, this trend accentuates as the temperature increases until at a certain temperature the deformation becomes entirely permanent. So high temperatures, however (which are those attained in the extrusion heads or in the injection-moulding presses), cannot be adopted in manipulating resin pipes already shaped, for these lose their consistency and cannot be further processed without suffering damages, so that any temperature above the Vicat point and which may be practically used allows to perform the process of the invention in a more or less perfect way.

In practice, temperatures in the range 140° C.—150° C. are well adapted to the purpose for rigid PVC.

If, conversely, the deformation is effected at a temperature considerably lower than the Vicat softening point, when the material has but little plasticity, apart from the great stresses then required to effect it, the material loses its strength and recovery and may even break and it is not possible to restore its original shape merely by heating it in a non-constricted state. When this occurs, the temperature is too low in order that the heating prior to reduction in diameter comprised in the process of this invention might be effected.

In conclusion the liner of PVC or other vinyl polymer should be heated before being passed through the die at a temperature at which it can be sufficiently deformed as to pass through the die without losing its strength and recovery and without acquiring a permanent deformation, so that, when it is heated again above the Vicat point or in the vicinity thereof in a non-constricted state, it may resume its original diameter or a diameter not too much lower. This will occur in the neighbourhood of the Vicat softening point and even very much above it, within a rather wide temperature range, as it is not essential that the deformation of the liner should tend to disappear completely in the course of the subsequent heating and temperatures at which a greater or a smaller portion of the deformation is permanent, can be adopted as it will be better explained hereinafter.

The essential point is that the criteria set forth above make it possible to determine the process temperatures for each material.

The invention will be better understood through the following description of some embodiments, illustrated in the accompanying drawings.

In the drawings:—

Fig. 1 shows in a diagrammatical fashion a way in which the process can be performed;

Fig. 2 shows a detail of a variant of the process of the invention;

Fig. 3 shows a detail of the product obtained;

Figs. 4 and 5 show another way of carrying out the invention;

Figs. 6 and 7 show devices used in carrying out the process of Figs. 4 and 5;

Figs. 8, 9 and 10 show details of other embodiments of the invention;

Figs. 11 to 13 inclusive illustrate three phases of a further thermal-mechanical treatment according to another embodiment of the invention, and

Fig. 14 shows the structure resulting from the last mentioned treatment.

Numeral 10 designates a metal pipe having an inner diameter "A", said pipe being mounted on two supports 11 and 11', so that the axis of the pipe is the dash-and-dot line of Fig. 1.

At a little distance from the open end of the pipe 10 and exactly coaxially therewith, the die 12 is situated, which will be suitably held in position by means not shown in the drawing.

The diameter of the die 12, indicated by "B" is slightly less than "A" and the said die is tapered towards pipe 10. If, by way of example, "A" is assumed to be 100 millimetres, "B" could be 97 to 99 millimetres.

In the vicinity of the die 12 there are located means for heating and means for cooling restricted portions of the PVC liner. Said means can be constituted, for example, by two tubular rings 13 and 14, each provided with holes in the inner periphery, which project towards the axis of the PVC liner, blasts of hot and cold air respectively: more precisely, cold air is supplied by ring 14 situated between die 12 and pipe 10, whilst hot air is supplied by ring 13 which is situated at the opposite side of the die.

A feed device diagrammatically represented by two rollers, 15 and 15[1], at least one of which is positively driven is placed before ring 13. In practice, the feed device may consist of conveyor belts or other devices.

The PVC liner 16, having an outer diameter "C" and suitably supported, by idle rollers 17 or like means, coaxially with pipe 10, is gripped by the device 15, 15[1] and thrust through ring 13, the diameter of which is large enough to keep it from touching liner 16. At this point the liner receives a hot air blast which brings it to the desired temperature, causing a partial softening of it.

Subsequently, the liner engages die 12. The diameter C is greater both than A and B: in the example described, it could be 102—104 millimetres. Of course, the choice of the exact diameters depends on the materials and temperature adopted, as it will be recalled later.

Liner 16, facilitated by the tapered shape of the die 12, becomes deformed reducing its diameter to pass through the die.

The liner 15, coming out of the die, is rapidly cooled by the cold air blast from ring 14, and consequently it retains an outer diameter very close to "B". Should the rapid cooling be inefficient, liner 16 could lose a part of its deformation i.e. it could acquire an outside diameter comprised between C and B; in this case, diameter B should be smaller. Other factors which have a bearing on the choice of this diameter are the characteristics of the plastic material, which latter may show a more or less marked tendency to revert to the original diameter in the initial stage of the cooling, and also the greater or smaller regularity of the cross-sections of the liner and metal pipe. As it is evident, if these cross-sections are somewhat irregular, a greater difference between the two respective diameters is necessary to allow the liner to be introduced into the pipe.

In any case, the liner 16 retains an outer diameter smaller than A and consequently it freely penetrates inside the metal pipe 10. This latter is then removed from its supports and the whole is heated, e.g. in an oven, at a temperature, for instance, close to that which the liner 16 has acquired before engaging the die 12.

In theory, it would be enough to heat the liner 16 without heating the pipe 10 or heating it to a smaller extent: in practice it is more convenient to heat both pipes together, but the possibility of operating only on the liner is not ruled out. The liner 16 tends then to revert to its original outside diameter C but it is prevented from so doing by the metal pipe which encloses it. Consequently, it presses against the wall of the metal pipe and strongly adheres thereto as it is shown by Fig. 3. It is apparent that the original diameter C should be selected great enough so as to cause these phenomena to occur.

Depending upon the characteristic of the plastic material and the adopted temperatures, the liner 16, should it not be enclosed by the metal pipe but introduced in an oven in a non-stricted state, would have a tendency to revert practically to the diameter C or, at least, to revert to an outside diameter D intermediate between B and C and more or less near C. The diameter C is to be selected so that the theoretical diameter D which liner 16 would assume in the oven if not constricted, and which can be determined empirically, be substantially higher than A. For example, if A is 100 mm, D could well be about 102 mm, and thus C might be, according to cases, 102 mm or a little more. The excess of the theoretical diameter D with respect to diameter A should exist at any operated temperature of the lined pipe. Consequently, the values of C and A should be referred to the lowest working temperature and if the lined pipes are to operate at a temperature lower than normal, the diameter C at normal temperature sould be correspondingly increased.

Of course, all the details of execution of the process may be varied. The cooling may be obtained by the use of liquids instead of gases, the heating may be obtained by liquids, by flames, by contact, by radiant-heat, or dielectric heating, as well as by gas. In particular, it is possible to use an electric oven, as it will be illustrated later, and this even could be of considerable length to allow of greater processing speeds. Instead of one die only, there could be a number of dies, to progressively reduce the diameter of the liner 16 or to prevent the untimely expansion thereof. The reduction in diameter of the plastic liner and its introduction into the metal pipe could be performed as successive and separate operations. Instead of having an intermediate feed device like the one illustrated in the drawings, pressure could be applied to liner 16 at one end or traction at the other, or both at the same time.

The reduction in diameter of the liner might be associated and generally is, to variations in length, in particular to elongations, and to variations in thickness as well. These other variations in the dimensions are set and eliminated together with the variations in diameter.

Another embodiment of the invention is illustrated in Fig. 2 where there is shown on an enlarged scale, an end of the pipe 10 on which a small collar 20 is mounted, which replaces the die 12. In this case the rapid cooling is lacking and heating is effected by a ring 13 situated in the immediate neighbourhood of collar 20 or by similar means. Collar 20 may be either removed on completion of the process or left in place. It may assume a number of different forms and can be connected to the pipe 10 in any suitable way, by a screw-thread or any other means.

Preferably, the liner 16 is a little longer than pipe 10 and is left to protrude therefrom at the two ends in order to facilitate the junction, by flange or by other means, of successive sections of lined pipes.

A still further embodiment of the process will be now described with reference to Figs. 4 to 7 inclusive.

Reference numeral 40 represents a resin liner the mean outside diameter of which is greater than the inner diameter of the metal pipe 41.

With reference to Fig. 6, the resin liner is previously provided with a tapered end, for example by pressing it into a tapered die 42, heated by resistors 43, and then removing it from the die. Subsequently the tapered end 44 thus obtained is inserted into a clamp 45 of any suitable type and formed for example as illustrated in Fig. 7 by an inner circular sleeve 46, a certain number of jaws 47, a screw or other locking means 48. The clamp is connected to a pulling device, for example via a metal cable 49, actuated by a traction element such as that diagrammatically indicated by the drum 50 and operated through a chain 51 by a motor (not shown) of any suitable type, preferably equipped with clutch and reduction gears and suitable control means.

Cable 49 together with clamp 45 is passed through the metal pipe 41 and through the small oven 52, and the clamp 45 is then mounted on the tapered end 44 of liner 40. Then, the pulling device is actuated. Liner 40 is thus drawn through the oven 52 and inside the open end 53 of pipe 41 which, in the case in point, acts as the die.

The pulling speed and the temperature of the oven 52 are controlled so that the resin liner 40 engages the opening 53 of pipe 41 when the liner 40 is sufficiently soft but still consistent enough to be capable of being pulled through without breaking. Thus, the resin liner penetrates into the metal pipe. When penetration is completed and clamp 45 has come out of the opposite end of pipe 41, the clamp is disengaged. At this stage, however, liner 40 has cooled, by contact with metal pipe 41 which latter, in turn, has been cooled by the ambient, air, or by a water spray applied to said pipe 41, or by any other means.

Due to the cooling, the resin liner shows a tendency to become detached from the metal pipe.

If a perfect contact is required, it is necessary to subject the resin liner to the final heat treatment previously referred to: this is preferably achieved by introducing the lined pipe into an oven, or into a heated liquid bath or a suitably heated chamber.

As is shown in Fig. 8, the metal pipe 41 can be introduced into a heated chamber 55, for example into a chamber in which hot air is circulated at the desired final treatment temperature.

A die 56 may also be positioned, as shown in Fig. 9, before the opening of the metal pipe. If the die is situated in the immediate proximity of the opening of the pipe, cooling of the resin liner may be omitted. As an alternative, the cooling may be performed as shown in Fig. 10, i.e. by adopting a somewhat long die 57 and cooling it, e.g. by means of a coil 58 through which a cooling fluid is circulated, so that the die itself cools the liner.

In the foregoing, it has been assumed to stat from resin liner stock cut into short lengths after a conventional extrusion operation: it is obvious, however, that the invention could be carried out by effecting the treatment herein described directly on the extrusion line before cutting the extruded liner into separate sections. With the mechanical means diagrammatically shown in the drawings several lined pipes have been prepared.

Example 1

A drawn steel pipe having an inside diameter of 100 mm, and a rigid PVC liner having a mean outer diameter of 103 mm and a thickness of 3 mm were used. The temperature of the resin liner when entering to steel pipe was 150° C. After the introduction and a spontaneous cooling, the pipe and liner were heated in a water bath at 100° C. for 15 minutes.

Example 2

A welded steel pipe having an inside diameter of 100 mm and a liner of PVC plastified with 10 per cent dioctylphthalate and having an average outside diameter of 103 mm and a thickness of 1.5 mm were used. The temperature of this latter at the entry into the metal pipe was 120° C. After the introduction and a spontaneous cooling, the pipe and liner were heated in an air oven at 90° C. for 10 minutes.

Example 3

A steel pipe consisting of a helically wound and lock-seamed steel band having an inside diameter of 100 mm, and a liner of PVC plastified with 10 per cent dioctylphthalate and having a mean outside diameter of 103 mm

and a thickness of 2 mm were used. The temperature of the resin liner at the entry into the metal pipe was 130° C. No final heating was performed and a fairly satisfactory engagement was nevertheless obtained.

EXAMPLE 4

The operations of Example 3 were repeated, except that the metal pipe was kept at 90° C., in the manner as shown in Fig. 8, and so left for 5 minutes after having completed the introduction of the resin liner.

EXAMPLE 5

The operations of Example 4 were repeated except that a liner of plastified PVC having a mean outside diameter of 105 mm and a thickness of 2 mm was used and a die having a diameter of 98 mm was placed before the metal pipe in the manner shown in Fig. 9.

EXAMPLE 6

A drawn steel pipe having an inside diameter of 200 mm and a rigid PVC liner having a mean outside diameter of 210 mm, and a thickness of 22 mm were used; before the metal pipe a die having a diameter of 196 mm was placed. The temperature of the resin liner when entering the die was 135° C. After the introduction of the resin liner into the metal pipe and spontaneous cooling, the pipe and liner were treated in a water bath at 105° C. for 15 minutes. Preferably the temperature of the final heat treatment lies between the Vicat softening point of the resin liner and 30° C. above it. A further embodiment of the invention, illustrated in Figs. 11 to 14 inclusive, implies a further thermal-mechanical treatment of the structure formed from a non-thermoplastic pipe and a thermo-plastic liner, obtained according to any embodiment of the invention. For a better understanding of this further treatment, it is necessary to point out a surprising effect of the treatments described till now.

As is known, synthetic resins, and particularly polyvinyl chloride and allied resins, have thermal expansion coefficients much higher than those of metals, even ten times as high. Now, with the hitherto described treatment the surprising result is achieved of annulling to a certain extent the thermal expansion of the resins.

Actually, if a liner, e.g. of polyvinyl chloride, introduced into a pipe, e.g. of iron, is subjected to a thermal treatment, e.g. at 100° C. or more, and adheres to the iron pipe, on subsequent cooling it ought to shrink in diameter much more than the iron pipe and to become detached therefrom. It is noted, instead, that this does not take place, i.e. until a certain temperature is attained, the polyvinyl chloride liner continues to adhere to the iron pipes as if it had the same coefficient of thermal expansion. This is explained by the inventors with the assumption that the the thermal contractions which the resin liner tends to undergo on cooling are compensated or annulled by the tendency of the liner itself to expand due to the latent internal stresses due to the reduction in diameter previously undergone by the liner, which stresses are set free by the thermal treatment. Likewise when the resin liner has been passed through the die and cooled and then introduced into the metal pipe and finally heated, the resin liner during the heating not only does not become elongated but, instead, it shrinks substantially. Reference will be made to the phenomena above described by the phrase "compensation of the thermal expansions", the term "expansion" being here intended in a general sense so as to include also the contractions on cooling. It has been ascertained, however, that said compensation takes place only down to a certain temperature and, below that temperature which varies according to the type of resin, the thermal expansions begin once more to occur as, or substantially as, in the non-treated liner or similarly.

For rigid and moderate plastified polyvinyl chloride, the border line temperature ranges from 60° to 75° C., and for highly plastified polyvinyl chloride it is correspondingly lower: it is impossible accurately to predetermine it, and, on the other hand, it must be remembered that it varies according to the particular lots of resin employed, according to the stabilizers, plasticisers, lubricants adopted and their quantity according to the treatments to which the resin has been previously subjected. It is known on the other hand that, due to the difference in thermal expansion between resins and metals, when a pipe structure formed from these two materials is heated, deformations, often conspicuous ones, occur, which hitherto severely hindered the use of such structures. Thus if a polyvinyl chloride liner is introduced into a steel pipe, the ends of the polyvinyl chloride liner are bent outwardly in order to form a flange, and, finally, the lined pipe is connected at its two ends to similar pipes and then through the pipeline thus formed a liquid is flown at 60° or 70° C., the iron pipe expands but little while the polyvinyl chloride liner expands much more. As the resin liner cannot freely elongate because it is bound to the length of the metal pipe, it forms swellings generally localized at the ends, which reduce the cross-section of the piping and originate points of weakness in the resin lining. To eliminate this drawback the length of the resin liner is fixed, according to the invention, with respect to that of the metal pipe at the temperatures at which the thermal expansion begins to occur again, when the compensating effects of the previously described treatment cease. The resultant structure is then allowed to cool while preventing any longitudinal shrink of the resin liner greater than the shrinkage of the metal pipe. The resin liner enters then into

tension in the cold: if now the lined pipe is brought to an high temperature, the resin liner does not tend any more to assume a length greater than that of the metal pipe or to swell.

This surprising result is interpreted by the inventors in the following way: until the temperature, at which the length of the resin liner has been fixed, is reached on heating, the tendency to stretch due to the thermal expansion is compensated by the internal tensions of the liner in the cold which are relieved little by little. At the temperature at which the length of resin liner has been fixed, an equilibrium is reached. Above this temperature the liner would tend again to stretch more than the metal pipe, but the latent tensions due to the heat treatment previously described, compensate the thermal expansions which continue not to arise.

The length of the resin liner can be fixed with respect to that of the metal pipe in a number of different ways, but the simplest of them all is to anchor the ends of the resin liner to the ends of the metal pipe, and this can be done in the simplest manner by the embodiment of the invention which will be illustrated with reference to Figs. 11 to 14 inclusive.

In Fig. 11 there is shown a flanged metal pipe 60, in which a resin liner 61 has been introduced after having been calibrated as already described to an outer diameter slightly smaller than the inner diameter of the metal pipe. Liner 61 projects from the two ends of the metal pipe 60. The pipe and liner are introduced into a heating chamber 62 for undergoing the heat treatment, so that their ends slightly protrude from said chamber. Chamber 62 is now heated, by hot air or other means and liner 61 expands and concurrently it shortens and adheres to the metal pipe. The length of liner 61 has been calculated so that even after this shortening, said liner continues to protrude from both ends of the metal pipe. The heat treatment can be carried out for instance at 100° C., if liner 61 is made of rigid polyvinyl chloride. The condition of the pipes after heat treatment is illustrated in Fig. 12. Chamber 62 is allowed to cool until it reaches a temperature of 70° C. approximately. At this temperature, which is maintained constant for some minutes, the still protruding ends of liner 61 are bent outwards against the flanges 64 of the steel pipe in order to form two flanges 65. Then metal rings 66 are applied against flanges 65, and are fixed by clamps 67 on flanges 64 as illustrated in Fig. 13.

Now, after having removed the pipe 60 and liner 61 in this condition from chamber 62, they are allowed to cool. Liner 61 cannot shorten more than pipe 60 because flanges 65 are locked and fix its length thereof: consequently the liner enters into tension as previously explained. On removing clamps 67 the lined pipe, as shown in Fig. 14, are ready for use at any desired temperature.

We repeat however that any suitable system as the use of tension bars which grip the two ends of the resin liner or of a rigid bar inserted into the resin liner and locked to the ends thereof, may be used for fixing the length of the resin liner with respect to that of the metal pipe at the transition temperature below which the thermal expansions come again into play. The length of the resin liner could also be fixed, at a given value independent of that of the metal pipe, or it is possible not to allow the resin liner to shorten even as much as the metal pipe.

Although the invention had been described with particular reference to either plastified or unplastified polyvinyl chloride, it is applicable not only to any vinyl polymers including polyethylene, but, in general, also to all those polymers which have plastic memory properties, as clearly set forth in the foregoing, and to which polymers it is consequently possible to apply the several processing operations described in the present specification.

WHAT WE CLAIM IS:—

1. A process for the lining of pipes of non-thermoplastic material with a liner of synthetic thermoplastic resin, comprising the steps of passing a synthetic resin liner having a mean outer diameter, as herein defined, greater than the inside diameter of the non-thermoplastic pipe through a die having an inside diameter less than the original mean outer diameter of the resin liner and less than or substantially equal to the inner diameter of the non-thermoplastic pipe, after having heated said resin liner to a temperature at which the synthetic resin undergoes deformations which may be temporarily set by cooling but are substantially eliminated by subsequent heat treatment, introducing the synthetic resin liner after its passage through the die into the non-thermoplastic pipe and subjecting the resin liner, when it has been inserted in the non-thermoplastic pipe, to a heat treatment comprising the steps of bringing said resin liner to a temperature sufficiently high so that the deformations due to the passage of the liner through the die are eliminated to the extent allowed by the presence of the non-thermoplastic pipe.

2. A process according to Claim 1, wherein the synthetic resin liner is rapidly cooled at its exit from the die.

3. A process according to Claim 1, wherein all the operations specified therein are effected in continuous sequence by mounting the die, the pipe and the liner coaxially.

4. A process according to Claim 1, wherein the synthetic resin liner is forced through the die by a device continuously applying pressure to the liner at a point located before the point at which said liner is heated.

5. A process according to Claim 1, wherein the resin pipe is drawn through the die by pulling.

6. A process according to Claim 1, wherein the synthetic resin is polyvinyl chloride or a vinyl copolymer and the temperature at which the resin pipe is heated before being passed through the die lies between the Vicat softening point and 140° C.

7. A process according to Claim 1, wherein the die consists of a collar or other device mounted on the open end of the non-thermoplastic pipe.

8. A process according to Claim 1, wherein the die consists either in the open end of the non-thermoplastic pipe to which the liner is to be applied or in a flange mounted internally of said open end, and wherein the resin liner is introduced into the non-thermoplastic pipe at a temperature which, in the neighbourhood of the open end of the non-thermoplastic pipe, is only slightly lower than the temperature at which the resin liner has been previously heated.

9. A process according to Claim 1, wherein the die is distinct from the open end of the non-thermoplastic pipe to which the liner is to be applied, and wherein the resin liner is cooled at its exit from the die so as to temporarily set the reduction in diameter due to the passage of said liner through said die.

10. A process according to Claim 1, wherein the die is distinct from the open end of the non-thermoplastic pipe to which the liner is to be applied and wherein the resin liner is cooled during its passage through the die so as to temporarily set the reduction in diameter due to the passage of said liner through said die.

11. A process according to any of the preceding claims wherein the final heat treatment of the resin liner consists in a heating at a temperature sufficiently high to allow said liner spontaneously increase its own diameters.

12. A process according to Claim 1, wherein the final heat treatment of the resin liner consists in allowing it to cool slowly while it is inside the non-thermoplastic pipe, and allowing it to stand, if required, for a few minutes at a sufficiently high temperature, so that the deformations due to the introduction into the non-thermoplastic pipe will not become set.

13. A process according to any of the preceding claims, wherein the temperature of the final heat treatment lies between the Vicat softening point of the resin liner and 30° C. above that point.

14. A process according to any of the preceding claims, wherein the temperature of the final heat treatment is substantially lower than the temperature at which the liner has been heated before being passed through the die.

15. A process according to any of the preceding claims, wherein the resin is rigid polyvinyl chloride and the temperature at which the resin liner is heated before being passed through the die is higher than 140° C., but not so high as to produce deterioration of the resin or to render the liner too plastic to be safely handled.

16. A process according to any of the Claims 1—14, wherein the resin is other than rigid polyvinyl chloride, being for example plastified polyvinyl chloride or a vinyl copolymer, and wherein the temperature at which the resin liner is heated before being passed through the die is a temperature at which the resin in question behaves as rigid polyvinyl chloride behaves at the temperatures set forth in Claim 15.

17. A process according to any of the preceding claims, wherein the resin liner is heated before being passed through the die by being passed through an oven, for example an electric oven.

18. A process according to Claim 5, wherein the resin liner is pulled by means of a clamp which tightly engages an end of the resin liner.

19. A process according to Claim 18, wherein an open end of the resin liner is previously tapered to facilitate its engagement by the clamp.

20. A process according to any of the preceding claims characterized in that, in addition to the operations set forth in said claims, the length of the resin liner is fixed with respect to that of the non-thermoplastic pipe by any suitable means, substantially at the temperature below which thermal expansions appear again and are no longer compensated by the treatment according to the preceding claims, then the resultant structure is allowed to cool while limiting the shortening, due to thermal contraction of the resin liner to a measure not greater than that of the shortening of the non-thermoplastic pipe, or by completely preventing the shortening of said resin liner.

21. A process according to Claim 20, wherein the resin liner is a rigid or moderately plasticized polyvinyl chloride liner and the temperature at which the length of the liner is fixed with respect to that of the non-thermoplastic pipe substantially lies between 60° C. and 75° C.

22. A process according to Claim 20, wherein the length of the resin liner is fixed with respect to that of the non-thermoplastic pipe by bending the ends of the resin liner outwardly to form flanges which are then locked in position on the ends of the non-thermoplastic pipe.

23. A process for the lining of pipes substantially as herein described with reference to and as illustrated in any Figures 1 to 13 of the accompanying drawings.

24. Lined pipes when produced by the process as claimed in any preceding claim.

TUBOVIT SOCIETA PER AZIONI,
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807,413 COMPLETE SPECIFICATION
3 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

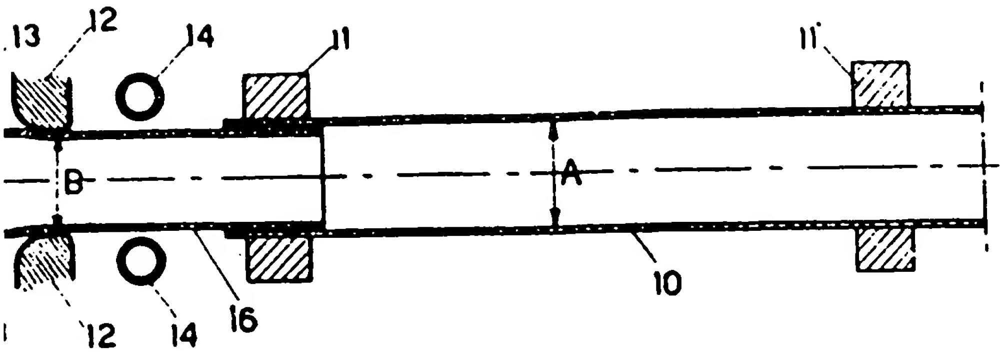
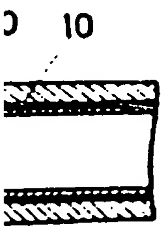


Fig.1



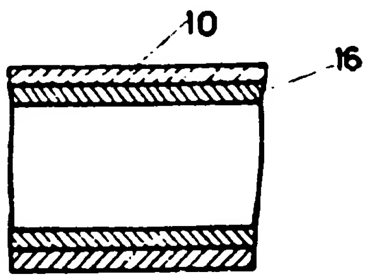


Fig.3

Fig.4

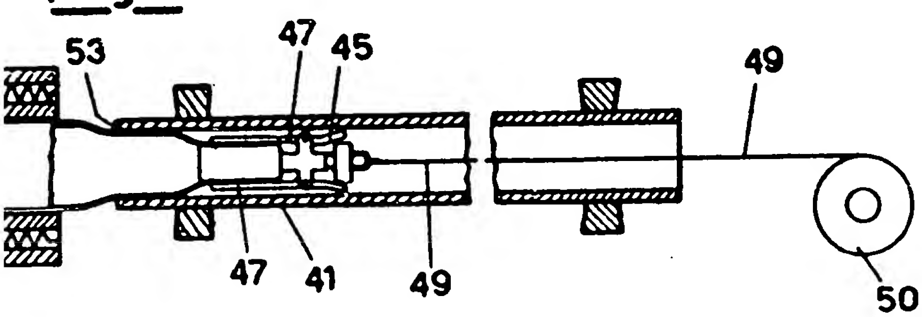
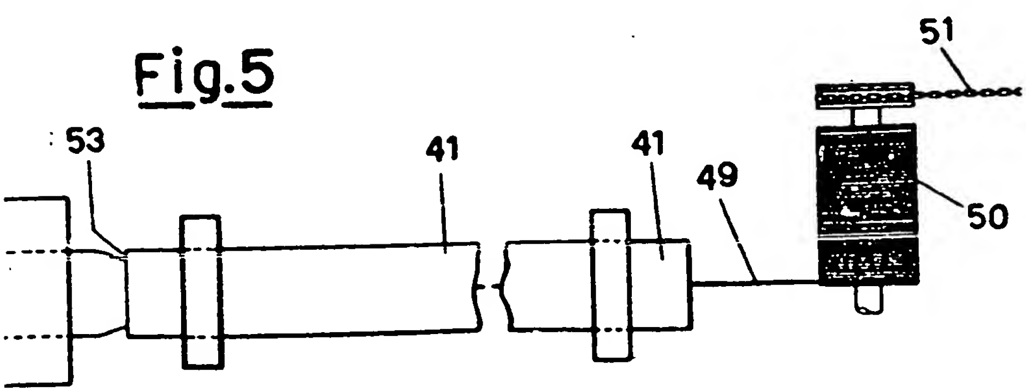


Fig.5



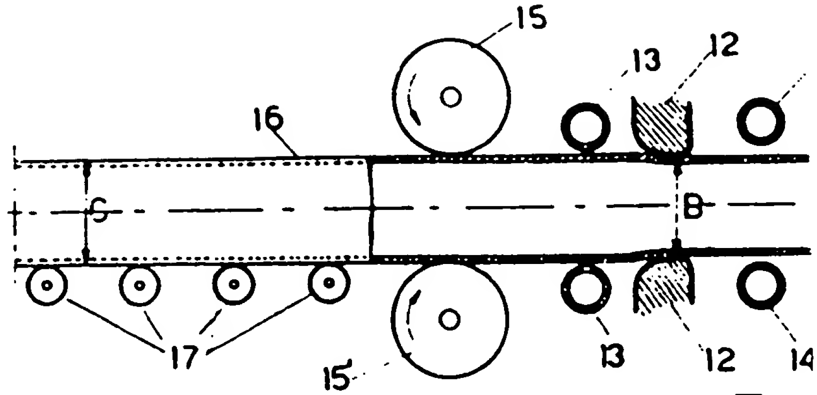


Fig.

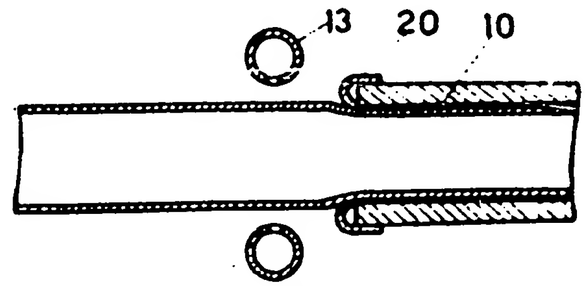
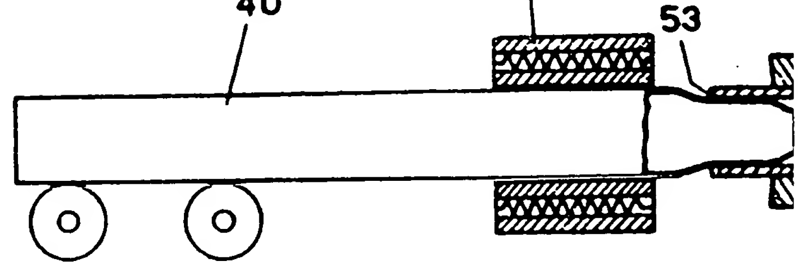


Fig.2

Fig.4



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